BLUE M Co.

312-385-9000

Model 1002-12PEX

TEMP CHAMBER 1-84

MOD 1002-12PEX

S/N RC3-700

1002-12 PEX

NO. IM-112

Date: October, 1966

Model # 1002-12PG

BLUE M ELECTRIC COMPANY, HIGH-LOW TEMPERATURE CHAMBERS
SINGLE STAGE - WATER COOLED

TABLE OF CONTENTS

1. General Information and Warranty I-1006-3 304-1
2. Installation Procedure I-1006-4
3. Control Equipment - Single Stage I-1006-6 116-8
4. Power-O-Matic 60 Saturable Reactor Control System TB.100
5. Memory Ring Dial Calibrating Instructions I-1007-1
6. Marshalltown Thermometer I-1008-3
7. Operating Instructions I-1006-13 116-7
8. Refrigeration System - Single Stage I-1006-10 212-11
9. Refrigeration System Data Sheet
10. Pressure Temperature Chart I-1006-11 116-9
11. Refrigeration Schematic
12. Refrigeration Parts List
13. Electrical Schematic
14. Electrical Parts List
15. Water Piping Diagram - Single Stage I-1006-2 116-13
16. Maintenance and Trouble-Shooting I-1006-12 116-11

MISCELLANEOUS

1. Alco Thermo-Expansion Valves
2. Alco Solenoid Valves . . . . . No. 173-2A
3. Alco Filter Driers . . . . . Bulletin No.200-2C
4. A-P Crankcase Pressure Regulator . . . . . No. R-700A
5. Penn Pressure Controls . . . . . #998-844-1 (Series 270-1272)
6. Penn Water Regulating Valve . . . . . Series 246, #2746-9
7. Corrosion Resistance of Stainless Steel . . . . . TB. 104
8. Copeland Service Manual
9. Temperature Conversion Chart

INSTRUCTION NO. I-1006-3

Date: October, 1966

GENERAL INFORMATION AND WARRANTY FOR BLUE M ELECTRIC COMPANY, HIGH-LOW TEMPERATURE CHAMBERS

FOREWORD

This manual is prepared to acquaint the operator with the equipment. A thorough understanding of the functions of the component parts of the chamber will assist the operator to attain proficiency of operation, and thus, produce test results compatible with the capabilities of the equipment supplied.

Blue M chambers are manufactured to the highest standards of the industry and are designed to give years of satisfactory service, if properly installed and maintained.

Schematic drawings, charts, etc., are included for the electrical wiring and refrigeration system along with other information for maintaining and servicing the equipment by a qualified refrigeration service mechanic having a thorough fundamental knowledge of the basic refrigeration principles. Should service be required, it is suggest that a company with previous experience in this type of work be selected. It is good practice to check with other users of test equipment to obtain the name of a competent service organization.

Due to the wide variety of equipment manufactured by Blue M and the always present problem of change in materials, these manuals are general in nature.

STORAGE AND SHIPPING

For storage or shipping of water cooled units in below freezing temperatures, the water cooled condensers, coils and water valves must be blown out with air. A charge of alcohol is then recommended for all water lines.

WARRANTY

The seller shall repair or replace, free of charge, such part or parts of the equipment sold that may prove defective in workmanship or material within one year from date of shipment. The warranty extended for parts does not include the replacement of refrigerant, oil, dehydrators and viewing windows. Defective parts must be shipped to the seller Freight Prepaid. Replacement or repaired parts shall be returned to the purchaser, Freight Collect. Labor to remove and re-install parts is the responsibility of the purchaser, unless otherwise noted on the contract covering this equipment.

BLUE M ELECTRIC COMPANY
138th & CHATHAM STREETS
BLUE ISLAND, ILLINOIS 60406

DJV/ls

INSTALLATION PROCEDURE
FOR BLUE M ELECTRIC COMPANY, HIGH-LOW TEMPERATURE CHAMBERS

INSTALLATION PROCEDURE

1. Carefully remove the crate from the cabinet and examine the equipment for any possible shipping damages.

2. The test chamber should be located on a level floor, which has a suitable firm foundation to withstand the additional load of the test chamber and its contents. Sufficient clearance should be left completely around the test chamber to facilitate servicing and also to give proper air circulation, if air cooled. In portable machines, care should be exercised to have the machine level when in operation.

3. Loosen the shipping nuts on the four legs of the compressor until it floats freely.

4. Open all compressor service valves and the condenser receiver service valve. Tighten packing glands and replace valve caps, making sure the copper gasket is in each cap.

5. On water cooled units, attach water supply line to the pipe coupling, identified as "Water Supply", located to the back or side of the compressor section. The size of the supply line will be equal to or greater than the pipe size of this coupling and must carry at least 40 PSIG pressure at all times. It is recommended that a shut-off valve be placed in the water line ahead of the machine.

6. On water cooled units, attach water drain line to another pipe coupling, located alongside the "Water Supply". This line must be equal to or greater than the pipe size of this coupling and may be connected to a pressure drain or floor drain.

7. Connect proper power source to chamber. Consult data plate, located on chamber, for required voltage and connected load. Feed power supply through a separate fused safety disconnect switch, supplied by others, to the terminals on the power terminal block located in the electrical compartment on the chamber. Grounding can be accomplished by connecting a separate ground wire from the metal frame of the unit to a suitable ground, such as water pipe or conduit. As the unit is furnished completely internally wired, these are the only electrical connections necessary.

8. Self-contained test chambers have compressors and other refrigeration equipment completely connected and no further connections must be made other than the electrical and water connections as previously mentioned.

9. Check blower motor rotation. This chamber is designed for a vertical air flow with air discharging from the top of the conditioning section and returning in the bottom. If unit is supplied for 3 phase operation, observe blower rotation. Reversing any two line leads will reverse a three phase motor.

10. Specifications

Consult specification data plate located on chamber for type refrigeration system, refrigerant charge, required water supply, voltage and connected load.

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CONTROL EQUIPMENT DESCRIPTIONS FOR VERSA-RANGE TEST CHAMBERS

In order to properly understand this chamber, the operator should be familiar with the various items which make the chamber perform as it was designed to. The following is a brief outline of the components used in this system and the functions of each.

1. POWER-O-MATIC 60 TEMPERATURE CONTROLLER

   Controls the temperature within the test space. Instructions covering this instrument should be referred to and read in detail before placing chamber into operation.

2. READY-READ TEMPERATURE INDICATOR

   Located on the control panel, monitors test space temperature. Refer to additional instructions in this manual for detailed information regarding calibration.

3. VOLTMETER

   Indicates the voltage applied to the chamber air heaters from the Power-O-Matic 60 saturable reactor control.

4. MAIN CIRCUIT BREAKER

   Completes the power to the blower motor, compressor, air heaters, and control transformer. In the event of a short circuit, circuit breaker will trip and disconnect power to the chamber. Control voltage is 120 volts furnished by means of a control transformer supplied from line voltage. With the circuit breaker in the closed position, the control circuit is energized thereby allowing the blower motor to run. The air heater is interlocked with the blower circuit through a set of contacts which prevent the air heaters from operating unless the blowers are in operation.

5. COOLING SWITCH

   Starts the refrigeration equipment, providing all the other contacts are calling for the cooling operation. This switch also completes the control circuit to the cooling capacity switch.

6. COOLING CAPACITY SWITCH

Places the hot gas by-pass capacity control valve in operation by energizing the hot gas solenoid valve. With the hot gas capacity control valve in operation, the refrigeration capacity of the system is reduced to approximately 50% of full rating. This switch is intended for use when maintaining steady state conditions in the range of approximately 0°F. to +120°F.

7. INTERIOR LIGHT SWITCH (OPTIONAL)

Controls the chamber light. During low temperature test, it is recommended that the light be used only as needed for viewing items under test, thereby reducing the introduction of additional heat.

8. CRANKCASE PRESSURE REGULATING VALVE

Limits the maximum low side pressure at the compressor inlet, to provide automatic motor overload protection. At conditions of overload, the valve modulates to prevent suction gas pressures at the compressor inlet above that for which the valve is adjusted. When the condition of overload [illegible] and the suction pressure drops below the valve setting, the valve assumes a wide open position during the balance of operation.

9. R-502 HIGH PRESSURE CUT-OUT

Is in series with the compressor. Pressures higher than the setting will cause the compressor to stop. When the discharge pressure goes down to the differential of the control, the compressor will again start.

10. SUCTION LINE DESUPERHEATER

Systems equipped with hot gas capacity control are supplied with a separate desuperheater expansion valve to meter liquid refrigerant into the suction line in order to maintain the temperature of the refrigerant gas returning to the compressor within allowable limits. This item is extremely important to compressor life.

CALIBRATING INSTRUCTIONS
BLUE M MEMORY RING DIAL SYSTEM
(PATENTED)

The Memory Ring Dial assembly allows calibration at all temperatures with pin point accuracy and extreme ease. The inherent ability of this control system to reproduce an exact temperature when control dial is returned to the same setting justifies the few minutes spent to calibrate it.

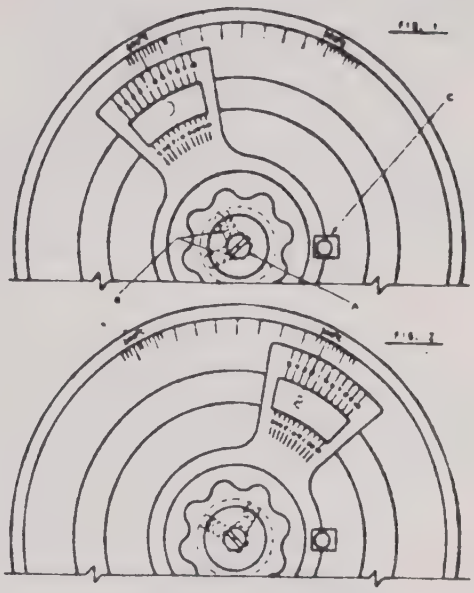
Dials are factory calibrated to a mid-range temperature when zero mark is aligned with the temperature graduation. (As shown in FIG.1, this dial is calibrated to produce a chamber temperature of 200°C. when set at zero.)

Movable pointer has a dial lock (Item C, FIG.1) which is provided to prevent the control from being accidently changed. Loosen thumb screw and slip pointer lock assembly out. Lock assembly may be secured in four (4) positions, or every 90° around the dial. This allows the movable pointer to rotate almost a full 360°. Dial lock must be secured in fixed holder or it will rotate with pointer instead of locking it.

When temperature control is factory installed, STEPS I and II may be omitted. STEPS I and II only apply when control is added to an existing piece of equipment.

STEP I - Using a separate means of indication, (thermometer, recorder, etc.) operate unit at a mid-scale temperature. In case of example shown in FIG.1, 200°C., stabilize unit at desired temperature as indicated on separate indicating instrument.

STEP II - After unit has stabilized at set temperature, carefully loosen control knob set screws. (Item B, FIG.1) These screws should remain in contact with control shaft and only be loose enough to slip forward or backward on control shaft. Loosen pointer locking screw. Item A, FIG.1. There is a Star Lock washer between plastic knob and aluminum pointer. Screw "A" must be loose enough to allow movement of pointer. Holding knob so that the Control Shaft cannot move, slip pointer until the zero mark is aligned with set temperature. Retighten dial lock screw "A" and set screws "B". Dial is now calibrated to set temperature.



STEP III - There are graduated reference numbers on pointer extending in both directions from zero mark which are correction factors for calibration error. Example shown in FIG.2, illustrates calibration procedure at other temperatures. When control setting is raised so that zero mark is aligned with 300°C. graduation, indicator shows that a temperature less than 300°C. is produced. Move control pointer slightly to the right (clockwise) to raise the temperature. When temperature indicator reads exactly 300°C., note that the 300°C. graduation is aligned with correction factor No. 2.

STEP IV - White ring on dial is painted to receive pencil or ball point pen. Write the correction factor (2) directly under 300°C. graduation. Now, whenever control is returned to 300°C., the correction factor (2) will appear in pointer window, automatically indicating proper control setting to obtain exactly 300°C. All other points are calibrated in the same manner. Dial can be calibrated during normal use by marking correction factor each time a new temperature is used.

If there are any further questions, feel free to contact the factory at any time.

BLUE M Electric Company
CORPORATE HEADQUARTERS: BLUE ISLAND, ILLINOIS 60406
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MANUFACTURERS AND ORIGINAL DESIGNERS OF CONSTANT TEMPERATURE CONTROLLED EQUIPMENT

CALIBRATING INSTRUCTIONS FOR BLUE M READY-READ TEMPERATURE INDICATOR

The Ready-Read Temperature Indicator is actuated by a liquid-filled thermal system employing a high torque bourdon spiral. There are no gears, hair springs, pinions or multiplying mechanisms to detract from its ruggedness and reliability. The dial arc is a full 270° on a 3" diameter scale and indicator accuracy is ±2%.

The Ready-Read Thermometer eliminates the irritation and expense of broken glass thermometers. In our judgement, it is more accurate than most small dial thermometers and more convenient than pyrometers with thermocouples. Temerature graduations are easily read and are in both Centigrade and Fahrenheit.

The following instructions explain the use and calibration of Ready-Read Thermometers. In addition, pertinent background information on the liquid-filled thermal system is given.

GENERAL INFORMATION

BASIC READY-READ THERMAL SYSTEM

The basic Ready-Read thermal system is shown in Figure 1. The entire system is filled with a liquid that expands with an increase in temperature. The sensing bulb is a fine bore tubing immersed in the work chamber to measure the temperature. The capillary is also a fine bore tubing that merely "transmits" pressure changes from the sensing bulb to the "Bourdon tube". The Bourdon tube converts pressure changes into rotary motion, thus providing indication on the calibrated scale.

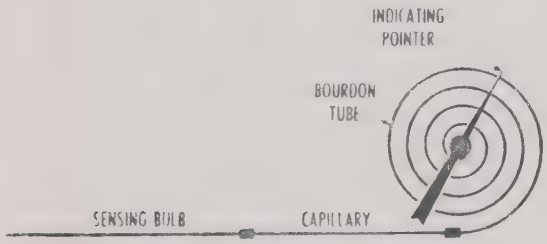


FIG. 1

AMBIENT TEMPERATURE INDICATION AND COMPENSATION

DO NOT ADJUST AMBIENT INDICATION WHEN UNIT IS FIRST RECEIVED AND INSTALLED REGARDLESS OF POINTER INDICATION.

The Ready-Read Temperature Indicator is installed on the unit and then calibrated after the unit has operated for at least one (1) hour. This procedure compensates for ambient rise within the control compartment due to normal heating of electrical components (motors, coils, saturable reactors, etc.). Since the Ready-Read is calibrated with the capillary exposed to relatively high control compartment temperatures, ambient indication will be lower than true ambient until the unit has operated for at least one (1) hour.

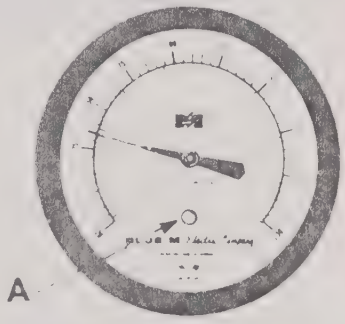
NOTE: Because the Ready-Read Temperature Indicator is not a "total immersion" temperature measuring device, it cannot be used to indicate varying "room" temperatures. Only the sensing bulb must be immersed in the medium to be measured.

The Ready-Read Temperature Indicator automatically compensates for ambient temperature variations experienced at the "case". Compensation is accomplished by a built-in bimetal opposing the rotation of the Bourdon tube.

CALIBRATION

Attach thermocouple of calibrating instrument directly to the Ready Read sensing bulb. Turn unit "on" and allow to operate for one (1) hour at its lowest controllable temperature. NOTE: For units having sub-ambient temperature capabilities, use ambient for the zero adjustment.

CENTIGRADE OUTSIDE BLACK
FAHRENHEIT INSIDE RED



ZERO ADJUSTMENT

1. Remove "Bezel" and glass cover from Ready-Read Temperature Indicator. Removal made by prying outward with a small screwdriver, etc., around the perimeter of the chrome plated ring.
2. Rotate adjusting screw "A" until the indicated temperature corresponds to the temperature shown by the calibrating instrument.
3. The zero adjustment is now complete.

SPAN ADJUSTMENT

1. Set unit for an operating temperature near maximum. (If unit maximum temperature is +343 C., set for +300°C. If maximum is +200°C., set for +200 C., etc.)

NOTE: For units having sub-ambient temperature capabilities, the span adjustment may be made on either side of ambient temperature. If greater accuracy is desired at low temperature, set unit for an operating temperature near its minimum. (If unit minimum temperature is -100 F., set for -100 F. If minimum is -40 F., set for -40 F., etc.)

2. Allow unit to operate at this high temperature for one (1) hour.

3. If the temperature shown on the Ready-Read Temperature Indicator is lower than the temperature shown on the calibrating instrument, the "span" is too short.
   Correct by pushing sensing bulb farther into the work chamber.

4. If the temperature shown on the Ready-Read Temperature Indicator is higher than the temperature shown on the calibrating instrument, the "span" is too long.

   Correct by pulling the sensing bulb farther out of the work chamber.

   Adjust the sensing bulb, in or out as required, approximately ½". Allow 10 to 15 minutes for the Ready-Read Temperature Indicator to stabilize. Continue this procedure until the Ready-Read indicates the correct temperature in accordance with calibrating instrument.

The span is now properly adjusted. Reseal into position with a high temperature material such as General Electric RTV Sealant.

NOTE: Changing the immersion depth has a marked effect on temperature indication at the high end of the scale. However, at the low end the effect is negligible. Referring to Figure 2, this is easy to understand.

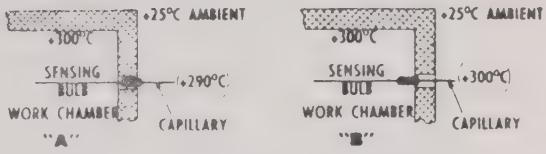


FIG. 2

At a temperature of +200°C. or +300°C., additional immersion exposes more of the sensing bulb to this high temperature. Indication therefore increases. At a low temperature (+25°C.), additional immersion accomplishes nothing, since the chamber's temperature and ambient temperature are the same.

OPERATING INSTRUCTIONS FOR BLUE M HIGH-LOW TEMPERATURE CHAMBERS (SINGLE STAGE)

Blue M environmental test chambers simulate a wide range of temperatures while maintaining precision temperature control. This requires compressor capacity control for satisfactory system performance.

Blue M offers a non-cycling, continuous operation refrigeration system, with a hot gas by-pass compressor capacity control system, used in conjunction with Power-O-Matic 60 Proportioning Saturable Reactor to produce straight line control of temperature.

Power-O-Matic 60 Reactor Controller offers inherent stability due to its non-cycling, proportional power input method of control. Exact amounts of power required to hold the temperature are applied to heating elements, changing only in response to load changes and line voltage changes. It is comprised of components whose characteristics do not change with age or usage. Minimal deviation from a set temperature will be a slight drift created by severe line voltage change and ambient temperature variations.

CONSTANT TEMPERATURE TESTS

To maintain a constant temperature in chamber, it will be necessary to bring temperature to set point and then add only heat required to maintain set point temperature. If set point is at a temperature below ambient, refrigeration must be used to remove heat that passes into chamber, heat added by fan and any heat dissipation from the product. Only the amount of refrigeration necessary to hold a given control point is desired. If set point is at a temperature above ambient, heat must be added to offset heat loss through chamber walls; however, only the amount of heat necessary to hold the controlled setting. These test procedures are recommended.

I. Low Temperature Test

Under this heading are considered only tests where full cooling capacity is desired to maintain required temperature. Temperature range is from minus 40°F. to approximately 0°F.

A. Turn main circuit breaker "ON". Power to entire chamber is supplied thru this circuit breaker. Blower motor will automatically start when circuit breaker is on.

B. Set control to desired temperature. Turn counterclockwise to lower temperature. Voltage impressed across heating elements can be observed on voltmeter. Refer to enclosed instructions for calibration.

C. Turn cooling switch to "ON" position. This will provide full cooling capacity of refrigeration system.

Equipment is now in operation.

II. Intermediate Temperature Tests

Under this heading are considered only where a limited amount of cooling is desired to maintain required temperature. This temperature range is from 0°F. to approximately plus 120°F.

A. Turn main circuit breaker to "ON" position.

B. Set control to desired temperature. Refer to enclosed instruction for calibration.

C. Turn cooling switch to "ON" position.

D. Turn cooling capacity switch to "ON" position. This switch places in operation hot gas by-pass capacity control valve, reducing capacity of refrigeration system to approximately fifty percent of full rating.

Equipment is now in operation.

III. High Temperature Tests

Under this heading are tests above approximately plus 120°F., where only heating equipment is required to maintain desired temperature.

A. Turn main circuit breaker to "ON" position.

B. Set control to desired temperature. Turn clockwise to raise temperature. Voltage impressed across heating elements can be observed on voltmeter. Refer to enclosed instruction for calibration.

Equipment is now in operation.

IV. RANGE-LOCK SETTING

This chamber is equipped with an overtemperature protection device. Once set, voltage to heating element CANNOT BE RAISED above a predetermined value EVEN IF CONTROL KNOB IS TURNED or if COMPLETE LOSS OF CONTROL BELLOWS IS EXPERIENCED, due to ruptured thermal system.

Since output voltage is determined by position of "I" lamination armature of inductor coil, it can be seen that if armature is mechanically "locked" after it has been positioned by bellows, voltage cannot be raised even if bellows is removed entirely. Setting procedure is as follows:

A. Allow oven to stabilize at operating temperature.

B. Remove dust cover from access hole on wiring panel.

C. Insert a screw driver thru access hole and engage slotted shaft (A).

D. Back shaft out (counterclockwise) very slowly, observing voltmeter while doing so.

E. When stop disc (B) touches armature (C), voltage will immediately drop from its initial reading because you will be closing the armature manually.

F. As soon as voltmeter drop is observed, stop turning adjusting screw. Turn adjusting screw back (clockwise) approximately 3/4 turn so that stop disc (B) is not in actual contact with armature (C).

IMPORTANT:

If armature is not free to move a small amount, control will be unable to compensate for a line voltage drop.

G. Maximum voltage is now permanently fixed at a value slightly higher than maximum requirement to maintain set temperature. In event of bellows failure, armature can only fall back as far as mechanical stop. Temperature will be maintained within confines of line voltage variations.

H. IMPORTANT:
Since temperature variation is now dependent upon line voltage fluctuation, Range-Lock should be set at a time of day when line voltage is at its highest level. This insures a limitation on maximum temperature that will be reached in event of failure.

I. If a temperature recorder is available, it is recommended that a 24-hour test run be made with Range-Lock set and control deliberately turned up to establish what maximum drift of temperature will occur in event of bellows failure. Line voltage regulation varies considerable throughout the country.

REFRIGERATION SYSTEM
FOR BLUE M HIGH-LOW TEMPERATURE CHAMBERS
(SINGLE STAGE)

GENERAL DESCRIPTION

This chamber consists of a single stage refrigeration system, using a thermostatic expansion valve. Compressor discharges refrigerant vapor under pressure to an oil separator where oil is trapped out and returned to compressor. Refrigerant vapor then passes into condenser, either air or water cooled, where heat is removed and vapor changed to a liquid. From condenser receiver, liquid flows through receiver liquid line valve, a liquid sight glass, a filter drier, through a liquid line solenoid valve and into high side of expansion valve. Expansion valve feeds low pressure liquid refrigerant to finned cooling coil, where heat is absorbed changing liquid to a vapor. Vapor then enters suction line and passes through a crankcase pressure regulating valve to suction side of compressor thus completing cycle.

Chambers supplied with a capacity control system are equipped with an electrically operated hot-gas by-pass capacity control solenoid valve, a suction line accumulator and a separate desuperheating expansion valve. In operation, hot gas by-pass valve is installed between compressor discharge and low side of refrigeration system, with a solenoid valve installed ahead of hot gas by-pass valve. When solenoid valve is in "closed" position, system is operating at full capacity. When solenoid valve is in "open" position, a reduced cooling capacity of approximately fifty percent will be produced. Due to high temperature of hot gas, a desuperheating expansion valve is necessary to meter liquid refrigerant into suction line and mix it thoroughly with by-passed hot gas in order to keep temperature of refrigerant vapor returning to compressor within allowable limits. A suction line accumulator serves as the mixing chamber and protects compressor from liquid flood-back.

This system contains all safety devices usually encountered on commercial applications, which includes a high pressure cut-out control, thermal motor overload protection and a high pressure relief valve. On water cooled units, there is also a water regulating valve to control flow of water to condenser in accordance with requirements.

PUMPING DOWN THE SYSTEM

To pump down system, close receiver outlet service valve, start compressor and continue running until low side gauge pressure reads "0" P.S.I.G.

refrigerant charge has then been condensed and is being held between compressor discharge service valve and receiver outlet valve.

VAPOR CHARGING SYSTEM

In many cases, a low refrigerant charge is caused by an obvious leak. Where there is no possibility that air and moisture have entered system, it is only necessary to repair leak and add refrigerant to system. Addition of refrigerant is carried out by vapor charging. Following procedure should be taken:

1. Back-seat suction service valve.
2. Loosely connect line from low side of tap of service manifold to suction service valve gage port.
3. Connect line from center tap of manifold to upright refrigerant cylinder.
4. Back seat discharge service valve.
5. Loosely connect line from high side tap of service manifold to discharge service valve gage port.
6. Purge vapor from cylinder up to compressor discharge valve.
7. Tighten high side service valve connection at gage port.
8. Purge vapor from cylinder up to compressor suction valve.
9. Tighten low side service valve connection at gage port.
10. Turn discharge service valve 1/4 turn off back seat.
11. Turn suction service valve 2 complete turns off back seat.
12. Pressurize system to full cylinder pressure and make final leak check.
13. Start compressor and wait until head pressure and suction pressure stabilize. Admit refrigerant from cylinder by adjusting cylinder valve to maintain a refrigerant vapor flow at a 10 to 15 pound pressure differential.

    From time to time, note suction pressure with cylinder valve closed.

From time to time, note discharge pressure to see that it does not rise above what would normally be expected under usual operating conditions. For air cooled systems, ambient temperature plus 30°F. converted to refrigerant saturation pressure should approximate discharge pressure.

14. Correct refrigerant charge can be checked easily by viewing sight glass, installed in liquid line, and observing compressor operation. If system is short of refrigerant, flash gas, in form of bubbles, can be seen rushing through glass. When sight glass indicates a solid liquid flow, system is charged. You may continue to add a small holding charge to system for reserve, however, make sure total charge does not exceed liquid receiver capacity.

15. When system is properly charged, back seat suction and discharge service valves and bleed pressure from both gage lines through manifold charging port.

16. Replace cap on cylinder valve and install flare plugs in open ends of charging and gage lines. Replace plugs in gage ports of service valves.

NOTE: If cylinder pressure drops too low for charging before job is completed, place cylinder in a pan or bucket of warm water between 80°F. to 110°F. Never apply heat to cylinder with a torch or never heat cylinder over 125°F.

LEAK TESTING

Leak testing may be done by same methods employed on any commercial installation. Use either a Halide torch or electronic leak tester. Extra care in leak testing will save both time and money.

OIL

Motor compressor assembly is hermetically sealed and should be checked by a competent refrigeration serviceman periodically. Oil recommended to be used for compressor is Suniso #5G. Only enough oil should be added to bring oil level to recommended level. This can be determined from compressor manual. Excessive amounts of oil in system tend to reduce heat transfer and increase temperature differential of evaporator and condenser.

MAINTENANCE

This system can be serviced with same tools, leak detector, gages and accessories as are required for normal commercial refrigeration service. Service this system with same care shown in good commercial practice. Remember that components and service methods are the same. Pressures are in normal operating range of standard commercial installation. Studying refrigeration schematic and information contained herein will enable service engineer to carefully and accurately analyze conditions for easiest maintenance and care. It is recommended that equipment be given regular checks for leaks and for oil level in compressor. Time between tests and checks should be determined somewhat from frequency of use and be in accordance with general commercial practice, which calls for at least two inspections per year.

PRECAUTIONS

1. Make certain only competent refrigeration servicemen perform inspections or service to this equipment.

2. If unit is air cooled, clean air cooled condenser every 30 days, or as often as required.

3. On water cooled units, make certain water is turned on to unit before starting any tests.

4. If unit is water cooled, make certain all water is removed from system, if unit will be moved or stored in temperatures below 32°F.

5. Make certain to loosen hold down nuts and see that compressor floats freely on mounting springs when installing or re-locating unit.

6. Make certain to tighten shipping bolts or hold down nuts before shipping or re-locating machine.

PRESSURE TEMPERATURE RELATIONS

Degrees Fahrenheit	R-12	R-22	R-502	R-13
120	157.6	259.9	280.3	
110	136.4	226.3	245.8	
100	117.2	195.9	214.4	
90	99.8	168.4	185.8	
80	84.2	143.6	159.9	520.8
70	70.2	121.4	136.6	458.7
60	57.7	101.6	115.6	402.3
50	46.7	84.0	96.9	351.2
40	37.0	68.5	80.2	304.9
30	28.5	54.9	65.4	263.2
20	21.0	43.0	52.5	225.7
10	14.6	32.8	41.1	192.1
0	9.2	24.0	31.2	162.1
- 5	6.7	20.0	26.8	148.7
- 10	4.5	16.5	22.8	135.4
- 15	2.4	13.2	19.0	123.5
- 20	0.6	10.1	15.5	111.7
- 25	* 2.3	7.4	12.3	101.3
- 30	* 5.5	4.9	9.4	90.9
- 35	* 8.4	2.7	6.7	81.8
- 40	* 11.0	0.5	4.3	72.7
- 45	* 13.3	* 2.6	2.1	64.6
- 50	* 15.4	* 6.2	0.0	57.0
- 55	* 17.3	* 9.1	* 3.6	50.0
- 60	* 19.0	* 12.0	* 7.0	43.5
- 65	* 20.5	* 14.4	* 10.0	37.5
- 70	* 21.8	* 16.6	* 12.6	32.0
- 75	* 23.0	* 18.5	* 15.0	27.9
- 80	* 24.1	* 20.2	* 17.1	22.3
- 85	* 24.9	* 21.6	* 19.0	18.1
- 90	* 25.7	* 23.0	* 20.6	14.2
- 95	* 26.4	* 24.1	* 22.1	10.7
-100	* 27.0	* 25.0	* 23.3	7.5
-105	* 27.4	* 25.9		4.8
-110	* 27.9	* 26.6		2.1
-115	* 28.2	* 27.2		* 0.2
-120	* 28.6	* 27.7		* 4.5
-125	* 28.8	* 28.1		* 8.0
-130	* 29.1	* 28.5		* 11.4
-135		* 28.8		* 14.1
-140		* 29.0		* 16.8
-145		* 29.2		* 18.
-150		* 29.4		* 20.8

* Inches of Vacuum

MAINTENANCE AND GENERAL NOTATIONS FOR BLUE M ELECTRIC COMPANY, HIGH-LOW TEMPERATURE CHAMBERS

Blue M chambers are designed and manufactured to give years of dependable service, if properly installed and maintained. Normal care should be exercised when using the equipment. It is recommended that a maintenance program be set up whereby the equipment is checked at regular intervals to help maintain performance and reveal anything which needs adjustment or servicing.

1. Refrigeration System

These systems can be serviced with the same tools, leak detector, gauges and accessories as are required for normal commercial refrigeration service. Studying the refrigeration schematic and information contained herein will enable the service engineer to carefully and accurately analyze conditions for easiest maintenance and care. It is recommended that the equipment be given regular checks for leaks and for oil level in the compressors. The period between test and check should be determined somewhat from the frequency of use, and be in accordance with general commercial practice which calls for at least two inspections per year.

2. Refrigeration Oil

The oil recommended to be used for the compressor is Suniso #3G. Only enough oil should be added to bring the oil level to the recommended level. Excessive amounts of oil in the system tend to reduce the heat transfer and increase the temperature differential of the evaporator and condenser.

3. Blower Motor

In general, the external blower motors have sealed ball bearings, lubricated with silicone grease and do not require any additional lubrication.

If the blower motor is supplied with oil cups, the motor should be oiled with a few drops of NO. 20 Motor Oil, once a month.

4. Viewing Window

In any chamber in which there is a multipane glass window, a quick heat-up in temperature has been known to cause the glass to break. It is suggested that the chamber be brought to ambient temperature first and allowed to remain at that temperature for a period, before continuing the rest of the heat-up.

5. Power-O-Matic 60 Control

This control system is simple, extremely rugged and virtually maintenance free. Any electrical component failure will result in "cut-off" of reactor current. Inductor coil, reactor, transformer, rectifiers, capacitors and heating elements are all static devices, non-moving and non-wearing. If control system does malfunction, rectifier bridge should be checked for D.C. output. Silicon rectifiers can be damaged by line voltage transients. Replacement may be made by removing four screws holding bakelite panel to rear of control compartment. Maximum D.C. voltage should be 30V to 35 V to the reactor. For additional information please refer to Power-O-Matic 60 section in this manual.

6. Recording and Programming Instruments

The manufacturer's instruction manual covering these instruments should be referred to for detailed information regarding their operation and maintenance.

7. Precautions

a) Make certain only competent refrigeration servicemen perform inspections or service to this equipment.

b) Clean out all water line strainers to the unit once a month, or as often as required.

c) Make certain water is turned on to the unit before starting any tests.

d) Make certain all water is removed from the system, if the unit will be moved or stored in temperatures below plus 32°F.

e) Clean air cooled condenser every 30 days, or as often as required.

f) Make certain to loosen hold down nuts and see that the compressors float freely on the mounting springs, when installed or re-locating the unit.

g) Make certain to tighten shipping bolts or hold down nuts before shipping or re-locating machine.

BLUE M ELECTRIC COMPANY
138th & CHATHAM STREETS
BLUE ISLAND, ILLINOIS 60406

INSTRUCTION I-208
Price $5.00 Eac

INSTRUCTION and OPERATION MANUAL

BLUE M

POWER-O-MATIC-60®

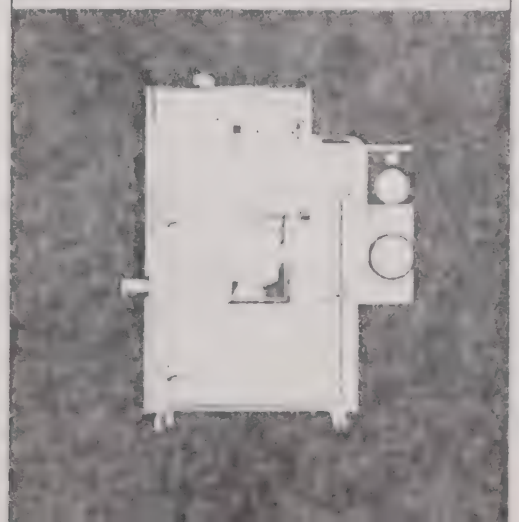
PATENTED

PROGRAMMER-CONTROLLER

BLUE M

IMPORTANT

THIS MANUAL SHOULD BE READ CAREFULLY BEFORE UNIT IS PLACED IN OPER ATION



BLUE M POWER-O-MATIC 60®

PATENTED

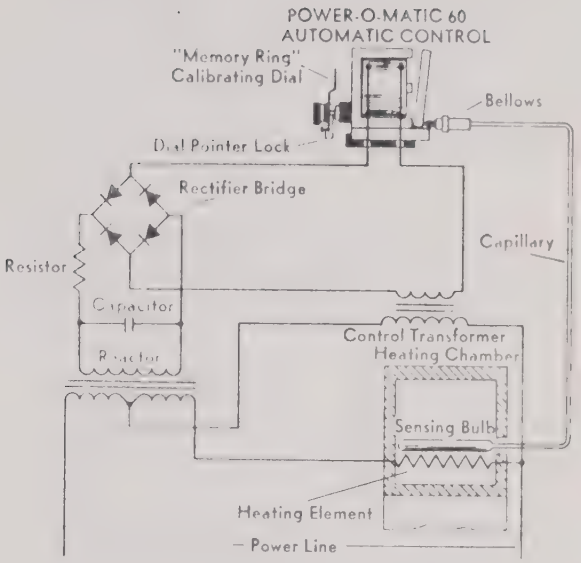
SATURABLE REACTOR PROGRAMMER-CONTROLLER

CONTENTS

	Page
POWER-O-MATIC 60 SYSTEM	
Important advantages	2
Description of operation	3
Temperature recorder	3
CAM CUTTING PROCEDURE	
Theory of operation	4
Reading point of tangency	4
Using master calibrating cam	4
Locating specific temperatures	5
Transferring reference points	5
Cutting blank cam	6
Cam-cutting facts to remember	6
OPERATING INSTRUCTIONS (Standard Programmers)	6
RANGE-LOCK PROTECTION	7
RATE-OF-RISE OVERTEMPERATURE PROTECTION (Optional)	7
TROUBLE SHOOTING PROCEDURE	8
PROGRAMMER – CONTROLLERS WITH ROTATIONS OTHER THAN 24 HOURS OR 7 DAYS	9
TYPICAL WIRING DIAGRAMS	Back Cover

The Power-O-Matic 60 Saturable Reactor Programmer-Controller is a fully proportional control using a variable "air gap" inductor to regulate the voltage applied to the control winding of a saturable reactor.

The saturable reactor, in turn, controls the voltage applied to the heating elements. For temperature/humidity control, two (2) Power-O-Matic 60 systems are used: One to control Wet Bulb Temperature, the other to control Dry Bulb Temperature. A block form diagram of the basic system is shown at right.

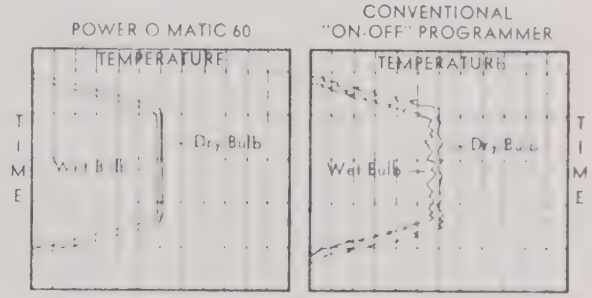


IMPORTANT POWER-O-MATIC 60 ADVANTAGES

The Power-O-Matic 60 System offers three important advantages over normal methods of controlling a predetermined temperature program. They are:

1. TRANSITION OF ONE TEMPERATURE TO ANOTHER . . . Extremely accurate degree of control throughout the transition. The Power-O-Matic 60 System, during a change, meters a gradually increasing or decreasing amount of power to the heating elements. This results in a smooth non-varying line as viewed on a strip chart recorder or a smooth curve as viewed on a circular chart recorder. With conventional "on-off" programmers, transitions from one temperature to another are extremely difficult to control since the controlling device is delivering either full power or none at all.

2. HUMIDITY CONTROL. Since the Power-O-Matic 60 System does not cycle heating elements "on" and "off", the control of both Wet Bulb and Dry Bulb results in smooth non-varying lines as viewed on the separate recorder. With conventional "on-off" programmers the lines are not smooth and relative humidity control is very erratic. An example is shown above, right.



As seen from the Power-O-Matic 60 chart, the Wet Bulb depression is constant which in turn means a CONSTANT RELATIVE HUMIDITY. On the conventional "on-off" control chart, Wet Bulb depression is never constant. For a typical Dry Bulb temperature of +65°C. at 95% R.H., the "on-off" programmer would allow relative humidity to range between approximately 82% and 95%.

3. SIMPLICITY AND RELIABILITY OF OPERATION DUE TO ELIMINATION OF MECHANICAL AND ARCING COMPONENTS. This is an extremely simplified programming system without any moving parts other than the rotating cam motor and bellows assembly. The basic control components, i.e., saturable reactor, inductor coil, transformer and silicon rectifiers are not expending themselves to sustain precise temperatures as when the control system employs relays, contactors, switches, etc.

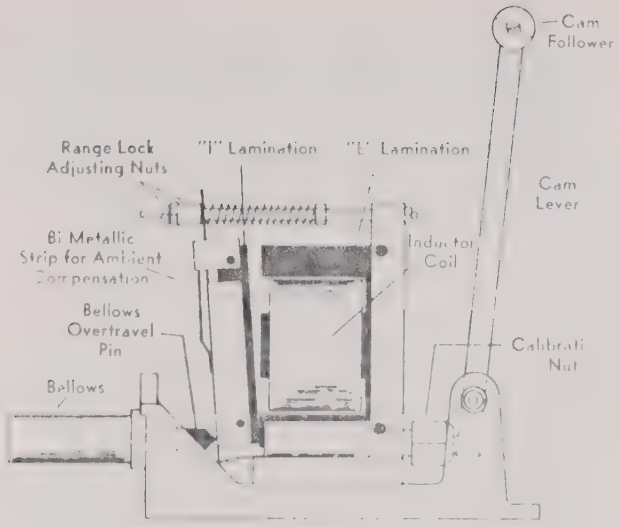


FIG. 1

DESCRIPTION OF OPERATION

(Refer to FIG. 1)

When the movable "I" lamination is at its farthest point from the stationary "E" lamination, voltage being applied to heating elements is at its maximum value. This is indicated by the voltmeter (approximately 90% of line voltage). When movable "I" lamination is closest to the stationary "E" lamination (i.e., in contact with it), voltage applied to the heating element is at its minimum value (approximately 6% of line voltage). Any intermediate position of the "I" lamination between these two extremes will result in an intermediate voltage value (between 6 % and 90 of line voltage) to the heating element. Expressed in simple terms, the power to the heating element is a function of the distance between the "I" lamination and the "E" lamination.

Assume a chamber is cold and the cam lever is moved to the left. This causes entire inductor assembly to move to the right, away from the bellows over travel pin, allowing the "I" lamination to move to the left. This increases the air gap and allows maximum voltage to be delivered to the heating element. As chamber temperature rises the temperature sensitive hydraulic bellows assembly responds to the temperature rise by means of a liquid filled sensing bulb located inside the heated chamber. As the liquid temperature increases, the liquid expands, forcing it through a capillary tube to the bellows. This causes the bellows to elongate and moves the bellows over travel pin to the right towards contact with the movable "I" lamination. As this motion continues, the "I" lamination is moved towards the "E" lamination, decreasing the air gap. As a result, power to the heating element is decreased. This motion and corresponding power reduction continues until a point is reached where the power input to the heating elements precisely balances all heat losses of the cabinet. A condition of equilibrium is reached and maintained.

No further motion of the bellows pin will occur until a temperature change occurs and a compensating action is required. This condition outlined would be equivalent to the cam lever riding on a perfectly concentric cam or on a concentric portion of a program cam. As long as the cam lever remains in this position, the temperature is maintained at one specific value. If the cam lever is moved further to the left, the same procedure will occur and stabilization at a higher temperature will result. If the cam lever is moved to the right, the temperature will reduce and stabilize at some lower temperature. If the cam lever is moved rapidly, the temperature change from one condition to another will be rapid. If moved very slowly, a corresponding slow rate of change occurs. From this it can be readily seen that if a circular cam cut to various levels is attached to the cam drive clutch assembly and the cam follower allowed to ride the outer edge of the cam, the unit will automatically perform a predetermined temperature cycle with closely controlled rates of change between stabilized conditions.

SEPARATE TEMPERATURE RECORDER

The temperature recorder supplied as standard is a separate unit of reliable commercial manufacture. Separate individual operating and maintenance manuals are included with each recorder.

No attempt has been made to indicate and record temperature from the same temperature sensing elements that control temperature. The controller has a sensing bulb(s) and the recorder has a sensing bulb(s). This offers many advantages.

A. The recorder pens are not "slaves" to the control action. They are free to monitor any and all variations that occur INDEPENDENTLY of the control system. If the controller is not functioning properly, the recorder will sense this and indicate it accordingly.

B. Separate sensing elements also provide flexibility when a reference to close tolerance application is required. The controller sensing element may be placed in an ideal location for tight response and accurate control. The recorder sensing bulb may be located in a position to most truly record the actual temperature in the work chamber. An example of this is Blue M Electric Company's typical sensing bulb locations as outlined below.

The controller sensing bulb locations will be close to the heating element for rapid shut off, fast response and responsive to fan, line voltage and/or other changes that will be in a position to concentrate air circulation for the same reasons. Usually this location is in the work chamber proper, but in the plenum chamber in close proximity to the heating element.

The recorder sensing bulb will be located within the work chamber at a location indicative of the average temperature of the chamber. Response is slower in this area, but it is not critical because the sensing bulb is only indicating what is happening and is not making corrective actions.

If the controller sensing bulb were mounted in the work chamber, response would be slower and temperature variations would occur. If the recorder bulb were located in the plenum chamber, it would indicate a greater temperature variation than actually exists in the work chamber. The indicated temperature would be: (Indicating a higher temperature than there is actually in the work chamber.) With conventional control systems where only one sensing bulb is used for both controls, a compromise location must be selected between these two ideal locations. Some reduction of both accuracy of indication and control tolerance must be made.

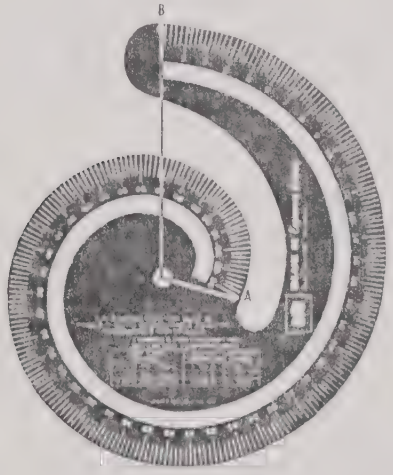
CAM CUTTING PROCEDURE UTILIZING MASTER CALIBRATING CAM

Our continuing program of providing the finest controlled temperature equipment has resulted in developing our own exclusive Master Calibrating Cam. It is an inexpensive, yet extremely accurate and simple measuring device providing a convenient means of laying out and cutting cams with pin-point accuracy in minimum time.

I. THEORY OF OPERATION

On Blue M Power-O-Matic 60 programmers, temperature is an indirect function of the distance from the center of the cam drive hub to the inner edge of the cam follower. Every position on the edge of the cam follower results in a specific work chamber temperature. Therefore, if the edge of the cam follower is positioned to obtain a specific temperature, and the distance from the cam follower to the center of the cam drive hub is accurately measured, we have a means of accurately locating specific temperatures.

FIG. 2

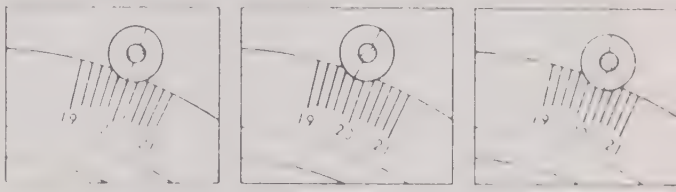


The master calibrating cam is essentially a very precise ruler in the shape of a spiral. Looking at Fig. 2 you will notice that the distance (measured in a horizontal plane) from the center of the cam to the outside edge of the cam varies as the cam is rotated. The distance from the center of the cam to point "A" is approximately 1-7/16", to point "B" approximately 4-5/8". By placing the cam on the cam shaft, any temperature within the capabilities of the chamber may be obtained by loosening the cam lock nut and manually rotating the cam. Rotating the MASTER CAM CLOCKWISE increases the distance between the cam drive hub and the edge of the cam follower, thus DECREASING CHAMBER TEMPERATURE. Rotating the MASTER CAM COUNTER-CLOCKWISE decreases the distance, thereby INCREASING CHAMBER TEMPERATURE. After chamber temperature has stabilized, as indicated by the recorder or some other accurate independent temperature indicator, the point of tangency between the cam follower and the outer edge of the calibrating cam is read directly from the calibrating cam as described below. By laying the calibrating cam over an uncut cam, the precise point at which the temperature was obtained may be transferred to the uncut cam.

II. READING POINT OF TANGENCY

A fundamental theorem of geometry states, "A straight line through the exact center of two tangent circles will intersect the point of tangency." The system used by Blue M utilizes a circle (cam roller) and a spiral (calibrating cam). Although the spiral is not actually a circle, the calibrating lines are plotted in a direction that would pass through the point of tangency of both the calibrating cam and the cam roller.

FIG. 4 FIG. 5



A reference line is provided on the movable washer on the cam lever. This provides a method of directly reading the point of tangency. This method is amazingly accurate because of the unaided eye's ability to perceive an angular deflection of two straight lines. As seen in Fig. 3, the line on the washer aligns perfectly with calibration line 20. It does not line up with 19.8 (Fig. 4) or 20.2 (Fig. 5). This indicates that the calibrating cam and the cam follower are tangent at calibration line 20. This method pin-points the actual cam follower position within 1/2 division (approximately .007 inch movement of the cam follower)

III. USING THE MASTER CALIBRATING CAM

STEP 1. CALIBRATION

The programmer must first be calibrated so that all temperatures within the range of the unit may be obtained within the limits of the calibrating cam.

NOTE: Once this calibration is performed, or, if the unit was supplied by Blue M with a cut and calibrated program cam, this step need not be performed.

(On Blue M dual programmers used for humidity control, the front control assembly is for wet bulb control and the rear control assembly is for dry bulb control.)

Blue M Electric Company programmers are supplied in 5 standard temperature ranges. These ranges and the numbers for calibrating reference temperatures are shown below:

For Control Range	Required Temperature	Ref No.
-73°C to + 204°C	—100°F to + 400°F	+ 75°C + 167°F	36
-29°C to + 100°C	—22°F to + 212°F	+ 50°C + 122°F	41
-7°C to + 204°C	+ 1°F to + 400°F	+ 125°C + 257°F	36
-10°C to + 343°C	+ 50°F to + 650°F	+ 200°C + 392°F	36
-38°C to + 538°C	+ 100°F to + 1000°F	+ 330°C + 626°F	36

Example: If the control's temperature range is +10°C. to +343°C., it is necessary to calibrate the programmer so that the chamber temperature is +200°C. when the calibrating cam is set at reference point 36. This is accomplished in the following manner:

1. Place the master calibrating cam(s) in position so that reference number 36 is lined up with the reference line on the movable washer. Turn cam motor switch "off".

   NOTE: Check cam follower(s) to be sure it is riding freely against outer edge of cam(s). Cam followers are properly aligned at factory and should not require adjustment. If ever required see Fig. 7.

2. Start chamber in the normal manner and allow temperature to stabilize for at least ½ hour.

3. If stabilized temperature is lower than desired, turn temperature calibration nut clockwise (move wrench up). If it is higher than desired, turn calibration nut counter-clockwise (move wrench down).

4. When adjusting calibrating nut, be sure to allow a sufficient time interval (½ hour minimum) before making additional adjustments.

5. Hold "E" lamination assembly with left hand when adjusting to relieve excessive torque on assembly.

6. Adjusting the calibrating nut shifts the entire operating range. This adjustment is used to calibrate the system at one point for a starting reference. After calibrating at one specific temperature by using the calibrating nut, all calibrations for all other temperatures must be made by altering the cam.

STEP 2. LOCATING SPECIFIC TEMPERATURES

Now that calibration is complete, all other temperatures needed for plotting the program must be located. Proceed as follows:

1. All "stabilized temperature" portions of the program MUST be located.

2. If a linear rise or fall time is required between two temperatures, 3 to 5 points must be located in order to plot a smooth curve. Example: If the program requires a linear fall from +250°C. to +175°C., the following points should be located: +175°C., +200°C., +225°C., +250°C. This will give four points through which a smooth curve can be drawn. If greater linearity is desired, more points can be located.

3. The points are located by rotating the calibrating cam. DO NOT ADJUST THE CALIBRATING NUT. When locating the points start at the lowest temperature required and continue upward in temperature until all points are located. Allow temperature to stabilize at least ½ hour before attempting to adjust cam. After temperature stabilizes, note reference number and resulting temperature. It is advisable to keep a permanent record of these reference numbers and resulting temperatures as they can be used on any other program for this particular unit. The patented "Memory" Ring on the master calibrating cam is ideal for this purpose.

   NOTE: All above adjustments are made with the cam switch "off." If stabilized temperature is slightly (one or two degrees) below the desired temperature, exact positioning is easily obtained by turning cam switch "on" briefly to raise the temperature.

STEP 3. TRANSFERRING REFERENCE POINTS TO UNCUT CAM.

TWO METHODS ARE OFFERED AND THE CHOICE IS DETERMINED BY THE ACCURACY REQUIRED.

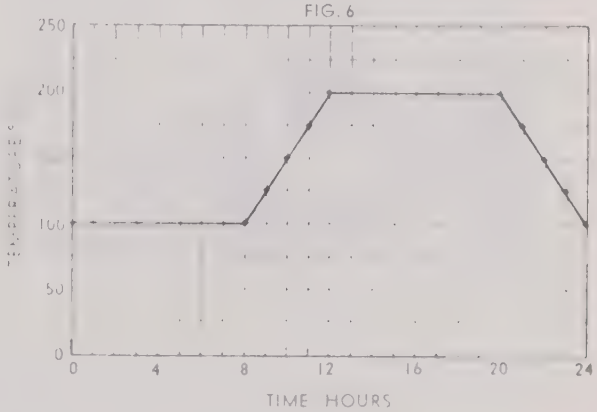
Method 1. The reference lines provided on the program cam can be used. Values between the numbers on the cam can be interpolated by eye. Temperatures of ± 2% of full scale range can be achieved by using this method.

Method 2. Temperatures can be transferred from the calibrating cam directly to the uncut cam. Using this method, accuracy is limited only by the skill of cam cutting technique. Place the master calibrating cam over the uncut cam so the two are concentric. (One suggested convenient method is to place the blank cam in the programmer and then place the master cam over it.) This insures that the two are concentric.

Carefully scribe the blank cam at the exact point of tangency for each recorded temperature vs. reference number.

Example: If the required program is as follows: start at +100°C., hold for 8 hours, +100°C. to +200°C. in 4 hours, hold +200°C. for 8 hours, +200°C. to +100°C. in 4 hours. See Fig. 6.

FIG. 6



NOTE: When laying out the program on the blank cam, a fixed starting point is required. This is particularly important when cutting dual cams for temperature and humidity programs. The cams must be aligned so the changes occur in both wet bulb and dry bulb systems at the proper time.

Assume the starting point is 9:00 A.M. The calibration number that yielded +100°C. must be scribed at 9:00 A.M. and at 5:00 P.M. (total of 8 hours). The calibration numbers that yielded +125°C., +150°C., and +175°C. must be scribed respectively at 6:00 P.M., 7:00 P.M. and 8:00 P.M. The calibration number that yielded +200°C. must be scribed at 9:00 P.M. and 5:00 A.M. (total of 8 hours) and the calibration numbers that yielded +175°C., +150°C., and +125°C. must be scribed respectively at 6:00 A.M., 7:00 A.M. and 8:00 A.M. The complete program is now transferred to the uncut cam. Connect the points of the temperature "rises" and "falls" in a smooth curve. A draftsman's French curve is ideal for this purpose.

V. CUTTING THE BLANK CAM

The cam should be rough cut with a band saw or equivalent. The temperature "rises" and "falls" should be hand-filed and then sandpapered to the proper contour. The stabilized portions of the cam can be trimmed by chucking the cam in a lathe. The aluminum is soft and cuts quite easily by rotating the chuck by hand. This insures a smooth flat surface and a cam shape that is perfectly concentric with the cam drive hub. The entire edge of the cam should then be LIGHTLY sandpapered to remove all burrs.

V. CAM-CUTTING FACTS TO REMEMBER

You should become thoroughly familiar with the following facts BEFORE cutting a program.

1. These are REVERSE cams. The lowest temperature is at the outer edge of the cam and conversely the highest temperature is at the inner edge. When the program is cut, it will be reversed from the pattern actually traced by the temperature recorder. A RISE ON THE CAM WILL RESULT IN A DROP IN ACTUAL TEMPERATURE.

2. Radial lines represent time. These are accurate and need not be checked. The drive motor revolves once every 24 hours or 7 days (other time increments available in special cases). A temperature rise cut to take place in 4 hours will occur in exactly 4 hours. Refer to chart on page 9.

3. In contrast to conventional programmers using "positive" cams, there is no limitation on temperature rise time. Since a temperature rise is a drop on the cam, the cam may be cut with a right angle drop allowing the cam lever to drop to a lower level on the cam. Temperature rise time will be limited only by chamber efficiency, K.W., etc.

4. The limitation exists when lowering the temperature. Lowering temperature is obtained by cutting a rise on the cam, raising the cam lever to a higher level on the cam. If this rise angle is too sharp, the cam follower will be at right angles to cam rotation and will lock. Drive motor delivers a high torque and usually will not stall but will strip the gears in the gear train. Maximum temperature reduction rate for all temperature ranges and rotation speeds is expressed as follows:

   FULL SCALE TEMPERATURE DROP IN 12% OF TOTAL ROTATION TIME.

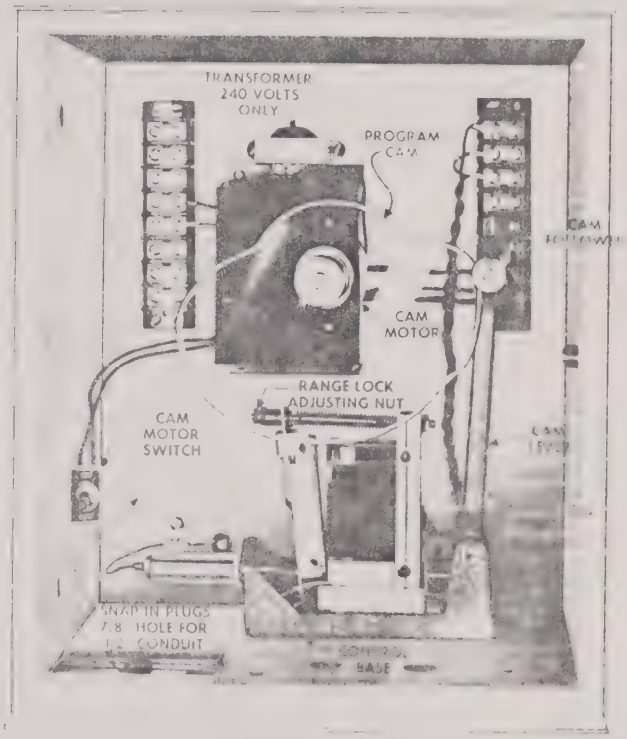
   On a 24 hour cam, a full scale temperature change should be on a curve covering not less than 2.9 hours.

5. To obtain a linear rate of change, do not cut a straight line between one temperature level and another. A careful examination of the cam will indicate that as the center of the cam is approached, the time lines are closer together; therefore a steeper angle of descent or ascent is required to change the same number of degrees per hour than is required at the outer edge of the cam where time line divisions are farther apart. A linear rate of change must appear on the cam as a curve. This curve is determined by subdividing the total rise into "X" number of degrees per hour, or ½ hour. Placing a dot on the cam at each of these points and drawing through them will produce the proper curve.

OPERATING INSTRUCTIONS (STANDARD PROGRAMMERS)

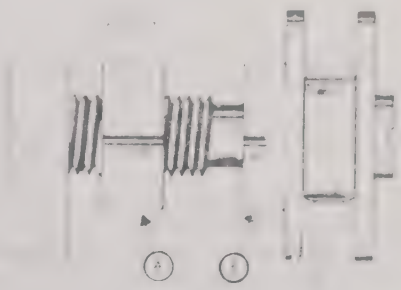
All Blue M Electric Company chambers with programming control will have specific instructions on installation, operation, etc. of the basic unit. The following instructions only apply to the programmer.

1. Place cut cam(s) into position on cam shaft with starting point in line with cam follower. Refer to Picture.



2. Check cam follower(s) to be sure it is riding freely against outer edge of cam(s). Cam followers are properly aligned at factory and should not require adjustment. If ever required see Fig. 7.

3. Turn cam motor switch "on." Cam should now be rotating and unit is in operation.



RANGE-LOCK PROTECTION

This control has a built-in overtemperature protection feature. As explained in previous sections, power to heating elements is a direct function of "E" and "I" lamination air gap. If we place a mechanical stop on movable "I" lamination to limit the air gap, the maximum power to the heating element is also limited. Maximum air gap obtainable may be regulated by turning Range-Lock adjusting nut against movable "I" lamination. This limits maximum voltage to heating elements regardless of the system's demands.

It must be realized that limiting the available voltage in this manner prevents programming of rapid temperature rises. RATE of temperature rise and required voltage are directly proportional; i.e., rate of temperature rise increases, voltage increases. Therefore, Range-Lock must not be set until the maximum voltage ever required for the entire program is known.

Range-Lock should be set so that maximum obtainable voltage is about 10% higher than maximum required for the program. Do this by removing cut cam and allowing cam lever to rest on cam shaft. Maximum voltage will now be indicated on voltmeter. Adjust Range-Lock adjusting nut until voltage falls to proper level. Depending on control's temperature range, this will permit only a 10°F. to 20°F. limited temperature rise.

RATE-OF-RISE OVERTEMPERATURE PROTECTION (OPTIONAL)

Rate-O-Rise Overtemperature Protection (OTP) is an exclusive Blue M development that insures safety for chamber and workload during any portion of the temperature program. This is accomplished by programming the OTP setpoint with a cam that is identical to, and synchronized with, the program cam. Required temperature differential is achieved by calibrating the OTP control so that its setpoint is slightly above program setpoint. See Fig. 8.

FIG 8

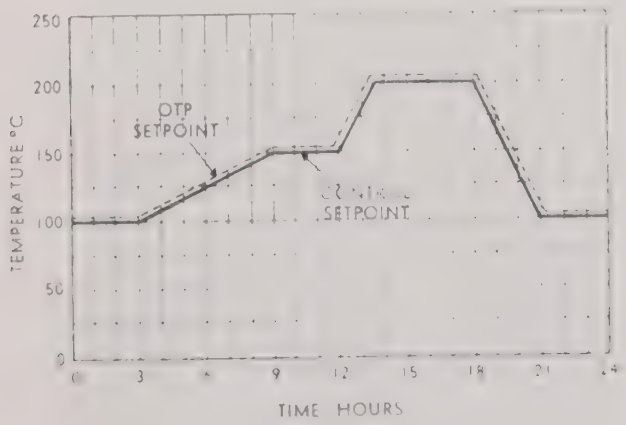
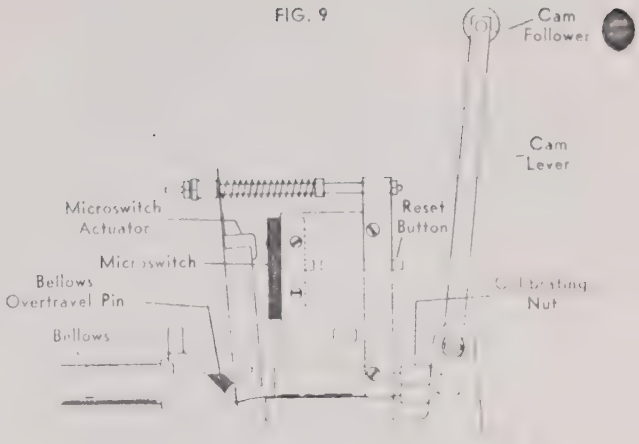


Fig. 8 is a graph of time versus temperature and is typical of a temperature program. Notice that as program setpoint changes, OTP setpoint changes to maintain the preset temperature differential. Clearly, ANY ABNORMAL TEMPERATURE AT ANY POINT IN THE PROGRAM will cause the OTP to "trip," thus shutting the chamber off.

FIG. 9



I. OPERATION

If the unit is supplied with factory cut and tested cams it will be only necessary to place cams on cam shaft and press the OTP reset button. See Fig. 9.

If the unit is not supplied with cut and tested cams, proceed as follows:

A. A cam, identical in configuration to the program cam must be constructed. Refer to cam cutting instructions

B. The cams must then be bolted together with screws and spacers provided. Cams must be synchronized with respect to both time and temperature.

C. Place cams on camshaft so cam followers rest on the lowest controlled, above ambient temperature portion of cam. NOTE: Lowest temperature will be found on the highest point of the cam.

D. Refer to chamber's instruction manual and place chamber into operation.

E. Press microswitch reset button. This closes OTP contactor. See Fig. 9. If microswitch will not reset, make sure that microswitch actuator is not too close to microswitch. If it is, turn calibrating nut clockwise (move wrench up) until microswitch can be reset, then turn nut an additional 1/4 turn. Allow unit to temperature stabilize.

F. Turn cam drive switch "on." Allow unit to run until entire program is completed. If the program is repetitive, i.e., +100°F. to +200°F. to +100°F. to +200°F., etc., allow programmer to complete one cycle. The temperature should be recorded on either a circular or strip chart recorder. See 1 and 2 below.

1. If the OTP trips during a steady state condition or during a temperature rise, this indicates either an overtemperature condition in the chamber or that the microswitch actuator is set too close to the microswitch. The presence of either condition can be determined by the recording.

2. If the OTP trips during a temperature fall, the OTP cam will have to be altered. Grind or file down temperature fall portion of OTP cam about 1/16 inch. See illustration. Run through program, and if OTP again trips at the same point, remove another 1/16 inch. Continue until OTP no longer trips during temperature fall.

Grind or File the Portion Indicated by the Dotted Line.

6. Determining how close the OTP is set is relatively simple. With cam motor switch "off" and cams in place, move "I" lamination of temperature control (rear) to the left. This will cause full voltage to be applied to heating elements (observe voltmeter), artificially inducing an over temperature condition. After OTP trips, observe temperature recorder and see how high the temperature climbed before the OTP shut the unit off. If a closer setting is required, turn calibration nut counter clockwise (move wrench down) slightly and try above procedure again.

TROUBLE SHOOTING PROCEDURE

As stated earlier, POWER-O-MATIC 60 is an extremely simple control with a minimum number of components. It is as failure proof as any control of comparable capability ever developed, and we cover it accordingly with our unique 5 year guarantee.

However, we cannot anticipate all conditions under which this control will operate — conditions which might conceivably present the threat of operational difficulty. Listed below are some common symptoms of malfunctions and their probable causes and corrections. Field-servicing with the aid of the following instructions will easily correct any operational difficulty:

1. No voltage indicated on voltmeter and unit comes up to temperature and appears to be operating properly.

   CAUSE — Defective voltmeter. Coil or pointer stuck or has an open coil. Remove control panel mounting screws and pull panel out for checking voltmeter and other internal components.

   CORRECTION — Replace voltmeter.

2. No voltage indicated. Unit does not come up to temperature.

   CAUSE — Loose or broken connection.

   CORRECTION — Inspect all connections. Tighten or repair as required.

   CAUSE — Current limiting resistor is open. Remove wiring shield for access to terminal strip where current limiting resistor is located.

   CORRECTION — Check resistor for continuity. Replace if defective.

   CAUSE — Filter capacitor shorted internally.

   CORRECTION — This capacitor located across D. C. terminals of rectifier bridge. Disconnect one lead from circuit. If voltage rises to approximately 50% of its normal maximum value with capacitor disconnected capacitor is shorted. Replace with new one.

   CAUSE — Burned out rectifier, or specialized bridge rectifier.

   CORRECTION — Replace with new part.

3. Maximum voltage appears on voltmeter continuously and cannot be varied by moving cam lever arm manually. Unit does not come up to temperature.

   CAUSE — Element circuit is open.

   CORRECTION — Inspect connections between element and reactor, and element and line. Tighten and/or repair if required. If connections are all right, check element for continuity. Replace if broken or burned out.

4. Maximum voltage appears on voltmeter, chamber temperature rises uncontrolled. Voltage can be varied by moving cam lever manually.

   CAUSE — Hydraulic bellows assembly has lost its liquid charge. It is not expanding with temperature rise.

   CORRECTION — Replace entire bellows assembly as follows:

   1) Loosen bellows lock nut so that bellows housing will rotate and bellows will remain stationary.

      WARNING: If this nut is not loose, capillary will be twisted apart when bellows housing is unscrewed.

   2) Remove bellows housing with small pipe wrench or pliers.

   3) Remove sensing bulb from interior of uncontrolled chamber and straighten capillary.

   4) Pull bellows assembly out through control cabinet door.

   5) Reverse above steps to install new bellows.

      Unit must be re-calibrated when new bellows assembly is installed.

   Chamber appears to be operating properly in all respects but temperature is slowly but continuously creeping upward, necessitating to be recalibrated downward every 4 or 5 days.

   CAUSE — Bellows assembly has a microscopic pin hole in it and is very slowly losing its charge.

   CORRECTION — Replace as outlined at

   [illegible] Unit should be operated for 2 or 3 days with [illegible] position at zero switch off to confirm [illegible] before replacing bellows.

   [illegible] incorrectly low and cannot be raised [illegible] temperature [illegible] is slow coming up to temperature [illegible]

   [illegible] 240 volt unit as connected from 208 volt line.

   CORRECTION — Install 208/240 V. booster transformer [illegible] and line connections. Contact factory for [illegible]

   CAUSE — Unit connected to 240 V. line but voltage [illegible] only low averaging from 210 volts to 215 volts [illegible] overloaded lines on this circuit.

   CORRECTION — Bring in new service to unit or install [illegible] transformer.

   [illegible] Capacitor connected across [illegible]

   [illegible] CORRECTION — Replace with [illegible]

   [illegible] heating element is grounded.

   [illegible] CORRECTION — Inspect heating element [illegible] element wire in contact with the unit frame. Repair [illegible] replace heating element, if necessary.

   CAUSE — Range Lock nut is too far in restricting movable [illegible] travel.

   CORRECTION — Back nut out [illegible] to [illegible] between laminations.

7. Chamber is operating properly in all respects, but temperature drift appears excessive. Does not always repeat the same temperature when cam is in the same position.

   CAUSE — This is usually an indication that the system is operating within its capabilities but the line voltage or ambient temperature is varying excessively.

   CORRECTION — Relocate unit in a more favorable location. (See specific installation instructions for the basic chamber.)

8. Cam does not rotate.

   CAUSE — Drive motor is burned out or defective.

   CORRECTION — Replace drive motor as follows:

   1) Remove wiring shield.
   2) Disconnect motor leads.
   3) Remove cam motor bracket.
   4) Remove motor from mounting bracket.
   5) Remove drive shaft from cam motor shaft.
   6) Reverse procedure to install new motor.

   NOTE: If this problem reoccurs, it is probably caused by a cam with too steep of a drop angle. Re-cut cam allowing more time to reduce temperature.

Contact factory or any Sales/Service facility for additional information.

PROGRAMMER-CONTROLLERS WITH ROTATIONS OTHER THAN 24 HOURS OR 7 DAYS

Blue M Electric Company supplies, as standard, either 24 hour or 7 day rotation lithographed cams. The time divisions on these cams can be interpolated for use at any other rotation. Refer to the chart below.

NOTE: The rotation of the cam drive can be determined from the data plate found in the programmer. The last number(s) indicate rotation. —1 = 1 Day, —2 = 2 Day,-1 Hr. = 1 Hour, etc.

STANDARD 24 HOUR PROGRAM CAM

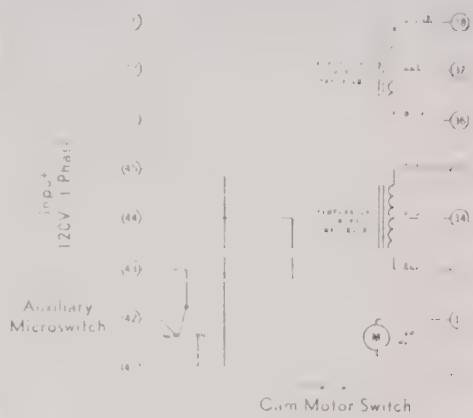
CAM DRIVE SPEED TIME REVOLUTION	TIME DIVS. AS MARKED ON CAM		NEW VALUES OF TIME DIVISIONS
	1 Hour	Represents	5/8 Minutes
15 Min.	8 "	"	5 "
	1 "	"	1 1/4 "
30 "	4 "	"	5 "
	1 "	"	2 1/2 "
1 Hour	2 "	"	5 "
	1 "	"	5 "
2 "	12 "	"	1 Hour
	1 "	"	7 1/2 Minutes
3 "	8 "	"	1 Hour
	1 "	"	10 Minutes
4 "	6 "	"	1 Hour
	1 "	"	15 Minutes
6 "	4 "	"	1 Hour
	1 "	"	20 Minutes
8 "	3 "	"	1 Hour
	1 "	"	30 Minutes
12 "	2 "	"	1 Hour
	1 "	"	2 "
48 "	30 Minutes	"	1 "
	1 Hour	"	3 "
72 "	20 Minutes	"	1 "
	1 Hour	"	1 1/4 Days
30 Days	4 "	"	5 "

STANDARD 7 DAY PROGRAM CAM

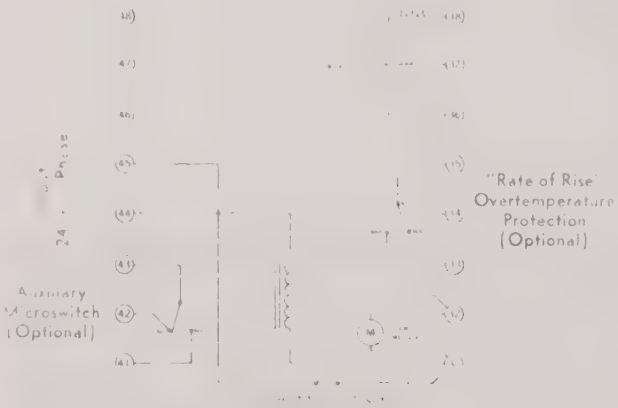
	1 Day	Represents	2 Days
14 Days	12 Hours	"	1 "

TYPICAL PROGRAMMER-CONTROLLER WIRING DIAGRAMS

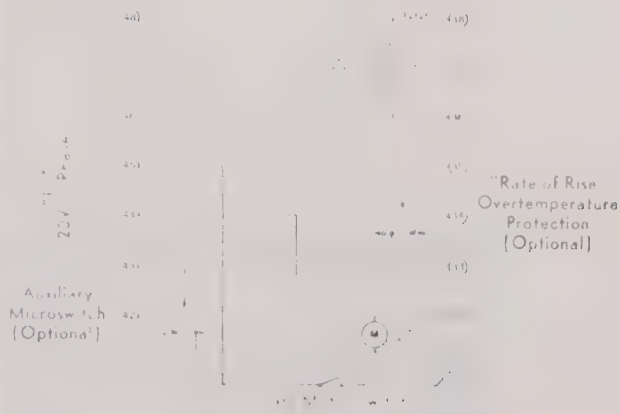
DUAL CONTROL PROGRAM CONTROLLER
240 Volts 1 Phase



DUAL CONTROL PROGRAM CONTROLLER
120 Volts/1 Phase



SINGLE CONTROL PROGRAM CONTROLLER
240 Volts 1 Phase



SINGLE CONTROL PROGRAM CONTROLLER
120 Volts/1 Phase

Corporate headquarters and plant, Blue M Electric Company, Blue Island, Illinois

Manufacturers and original designers of constant temperature controlled equipment.

ENVIRONMENTAL CHAMBERS

REFRIGERATED TEST CHAMBERS

WATER, OIL AND REFRIGERATED BATHS

LABORATORY AND PRODUCTION FURNACES

LABORATORY, TESTING AND PRODUCTION OVENS

STANDARD AND CUSTOM-ENGINEERED EQUIPMENT: −300°F. to +3000°F.

BLUE M

BLUE M *Electric Company*

CORPORATE HEADQUARTERS BLUE ISLAND, ILLINOIS 60406

Phones (312) 468 7755 385 9000 TWX 910 689 3533

MANUFACTURERS AND ORIGINAL DESIGNERS OF CONSTANT TEMPERATURE CONTROLLED EQUIPMENT

MODEL NUMBER: FTBR-12-15WS-DBF VOLTAGE: 240V/3ph/60cy

RP-345-3-4A | 2-20-67

Rev."A" | #22 added

ITEM NO.	DESCRIPTION	PART NUMBER	NO. REQD.
1	Motor Compressor	R12B-05	1
2	Discharge Vibration Absorber	Included In	Above
3	Charging Valve	Included In	Above
4	Condenser Receiver	Included In	Above
5	Water Regulating Valve	Included In	Above
6	Receiver Shut-Off Valve	Included In	Above
7	Pressure Relief Valve	Included In	Above
8	Liquid Indicator	R42-02	1
9	Filter Drier	R16-06	1
10	Liquid Line Solenoid Valve	R43A-03	1
11	Thermo Expansion Valve	R54A-07	1
12	Suction Vibration Absorber	R61-06	1
13	High Pressure Cut Out Control	R37B-01	1
14	Oil Separator	R36-02	1
15	Evaporator	C351-4	1
16	Accumulator	R01-03	1
17	Crankcase Pressure Regulator	R13C-02	1
18	Hot Gas By-Pass Solenoid	R43A-04	1
19	Hot Gas By-Pass Valve	R66-07	1
20	Liquid Line Solenoid Valve	R43A-03	1
21	Thermo Expansion Valve	R54A-02	1
22	Check Valve	R06-02	1
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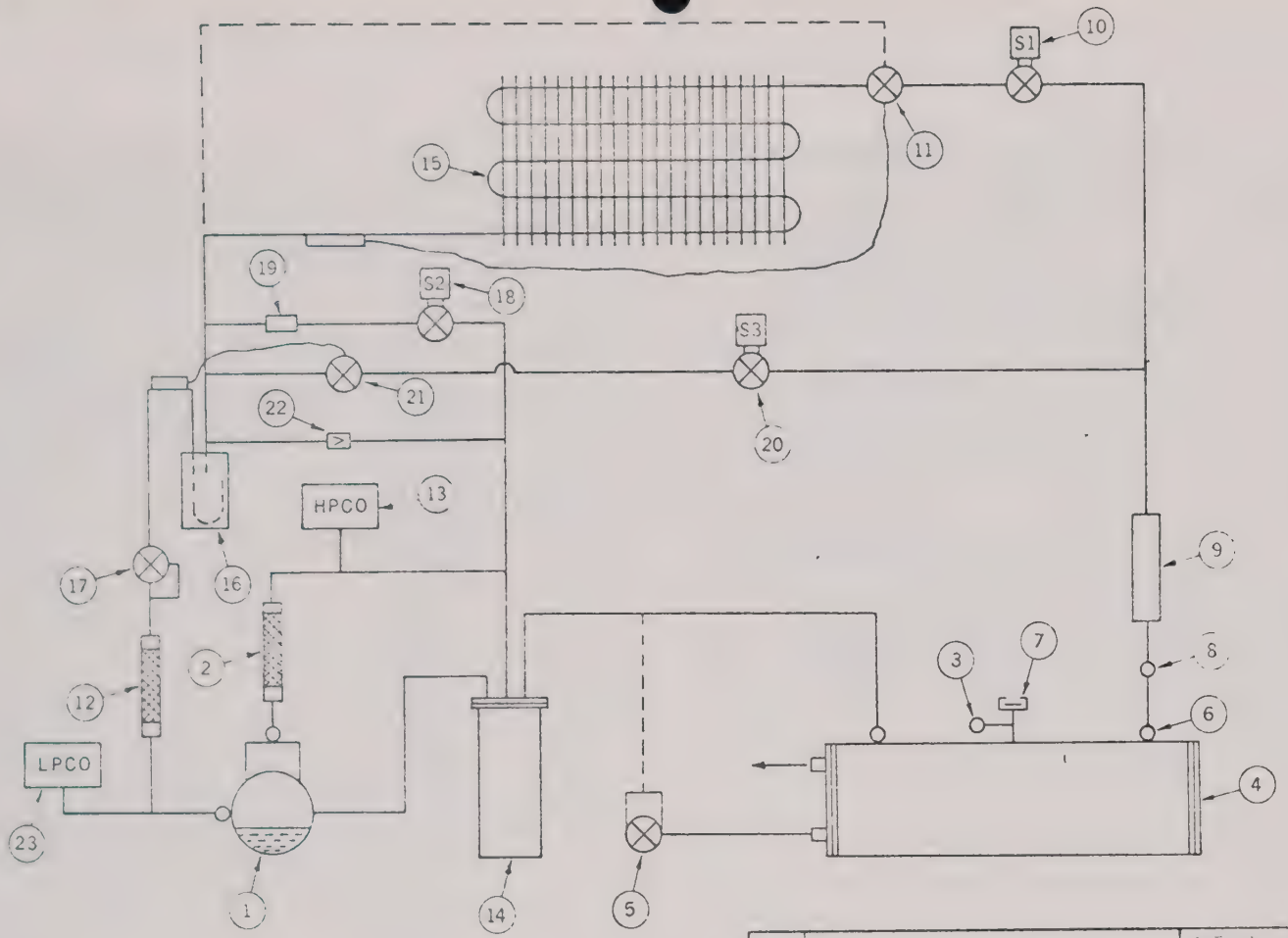
* PARTS NOT SHOWN.

Prices subject to change without notice. Parts shipped F.O.B. Blue Island, Illinois.
When ordering parts, give MODEL NO., SERIAL NUMBER, VOLTAGE and PART NO.

...mercial Condition Par...



A	#22 & #23 ADDED	2-20-67

BLUE M Electric Company

CARD NAME: REFRIGERATION SCHEMATIC

USED ON: SINGLE STAGE SYSTEMS

SCALE: -/-/-

DATE: 7-1-66

DRAWN:

CHECKED: WT

DRAWING NO.: RS-345-13

A

MODEL NUMBER 1002-12PG
VOLTAGE 480V/3PH/60Hz
MAX TEMPERATURE -40°C TO +93°C
MAX WATTS 5.5 (TOTAL LOAD)
INTERIOR DIMENSIONS 30H X 24D X 24W

PWD-1280-911-2
(PAGE 2)
THIS PARTS LIST TO BE USED WITH WIRING DIAGRAM
WD-911B

	DESCRIPTION	PART NUMBERS	REQ'D
1	BREAKER AMP	C16C	1 SET
2	[illegible] HEATERS	A121-707A	1
3	[illegible] WITH RESISTOR	E09-3	1
4	[illegible]	E13-7	1
5	[illegible] CIRCUIT POWER SUPPLY	E15A-2-2	1
6	[illegible] CONTROL	C03A-5-21	1
7	BELLOWS ASSEMBLY FOR ITEM 6	C11A-4	1
8	CONTROL TRANSFORMER	SUPPLIED W/ITEM #5	
9	BRIDGE RECTIFIER	SUPPLIED W/ITEM #5	
10			
11	CAPACITOR	SUPPLIED W/ITEM #5	
12	[illegible] SUPPLY FUSE	E19A-5	1
13	[illegible] SUPPLY SOCKET	SUPPLIED W/ITEM #5	
14	PANEL FUSE	E60R-1	1
15	MAIN PILOT LIGHT	E06B-2	1
16	RELAY	E02C-1	1
17	RELAY COIL	SUPPLIED W/RELAY	
18	CONTACTOR FUSE	E60R	3
19	COMPRESSOR FUSE	E60R	3
20	CONTROL CIRCUIT FUSE	E60A-2	2
21	CONTROL TRANSFORMER /120V 500VA	E17B-2-3	1
22	CHAMBER BLOWER MOTOR 1/3 HP	E13A-2-3	1
23	CHAMBER BLOWER MOTOR STARTER	E11A-1	1
24	CHAMBER BLOWER MOTOR STARTER COIL (C4)	SUPPLIED W/STARTER	
25	CHAMBER BLOWER OVERLOAD RELAY	SUPPLIED W/STARTER	
26	CONDENSER FAN MOTOR	[illegible]	1
27	[illegible] 1 1/2HP [illegible]	R30E-01	1
28	MOTOR COMPRESSOR STARTER [illegible]	E11A-1	1
29	MOTOR COMPRESSOR STARTER COIL (C2)	SUPPLIED W/STARTER	
30	FULL COOLING SWITCH	E16A-5	1
31	FULL COOLING PILOT LIGHT - BLUE	E06B-4	1
32	HIGH PRESSURE CUT-OUT (S5)	R37E-01	1
33			
34	DEFROST WATER TEMPERATURE CONTROL (BLIND SET)	C03A-3-2	1
35	DEFROST WATER SOLENOID VALVE (BY-PASS) (S3)	E14A-1-1	1
36	DEFROST WATER SOLENOID VALVE (MAIN) (S4)	E14A-3-1	1
37	HOT GAS BY-PASS SOLENOID VALVE (S2)	E14E-3-1	1
38	REDUCED COOLING SWITCH	E16A-5	1
39	REDUCED COOLING PILOT LIGHT - BLUE	E06B-4	1
40			
41			
42			
43	DOOR LATCH AND STRIKE	M02-D4	1
44	DOOR GASKET - SILICONE SPONGE	M05-A3-132"	1
45	DOOR GASKET - NEOPRENE SPONGE	M05-A4-[illegible]	1
46	[illegible] - FOAM RUBBER	M05-A5-[illegible]	1
47	[illegible] FOR [illegible]	M04-[illegible]	1
48	[illegible]	M04-A13A	AS REQ'D
49	TEMPERATURE INDICATOR	C01A-7	1
50	LOW PRESSURE CUT-OUT (S1)	R37C-01	1

	DESCRIPTION	PART NUMBERS	REQ'D
51	CHAMBER BLOWER OVERLOAD HEATER	E11D-[illegible]	1
52	CONTROL RELAY (C5)	E02C-5	1
53	CONTROL RELAY COIL (C5)	SUPPLIED W/RELAY	
54	COMPRESSOR OVERLOAD RELAY	SUPPLIED W/# 25	
55	OVERLOAD RELAY HEATER	E11D-[illegible]	
56	OVERTEMPERATURE PROTECTION MICROTROL ASSY.	C03A-3-2	1
57	ALARM BUZZER	E01-1	1
58			
59	PERCENTAGE TIMER	C12P-2	1
60	ELAPSED TIME METER	C12G-3	1
61	RESISTOR (OTP)	E03A-5-4	1
62	OTP PILOT LIGHT (AMBER)	E06B-1	1
63	OTP RESET DEVICE	C03C-4-1	1
64			
65			
66	OTP CONTACTOR	E02F-1-1	1
67	OTP CONTACTOR COIL (C7)	SUPPLIED W/CONTACTOR	
68	BELLOWS ASSEMBLY FOR ITEM #56	C11A-4	
69			
70	CAM DRIVE MOTOR ASSEMBLY - (24 HOUR) [illegible]	E10C-5-1	1
71	CAM DRIVE MOTOR [illegible]	E10C-1-1	1
72	AUXILIARY MICROSWITCH, DUAL (CAM ACTUATED)	E10B-4	1
73	CAM DRIVE MOTOR SWITCH	E10A-2	1
74	PROGRAMMER CONTROLLER	C07A-3-3	1
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87	[illegible]		
88	[illegible]		
89			
90			

DATE: [illegible] BY: [illegible] CHECKED: [illegible]

LINE NO	VOLTAGE	AMPERES
L1	480V	1.2
L2	480V	6.2
L3	480V	11.4

REVISION	REASON	DATE	BY

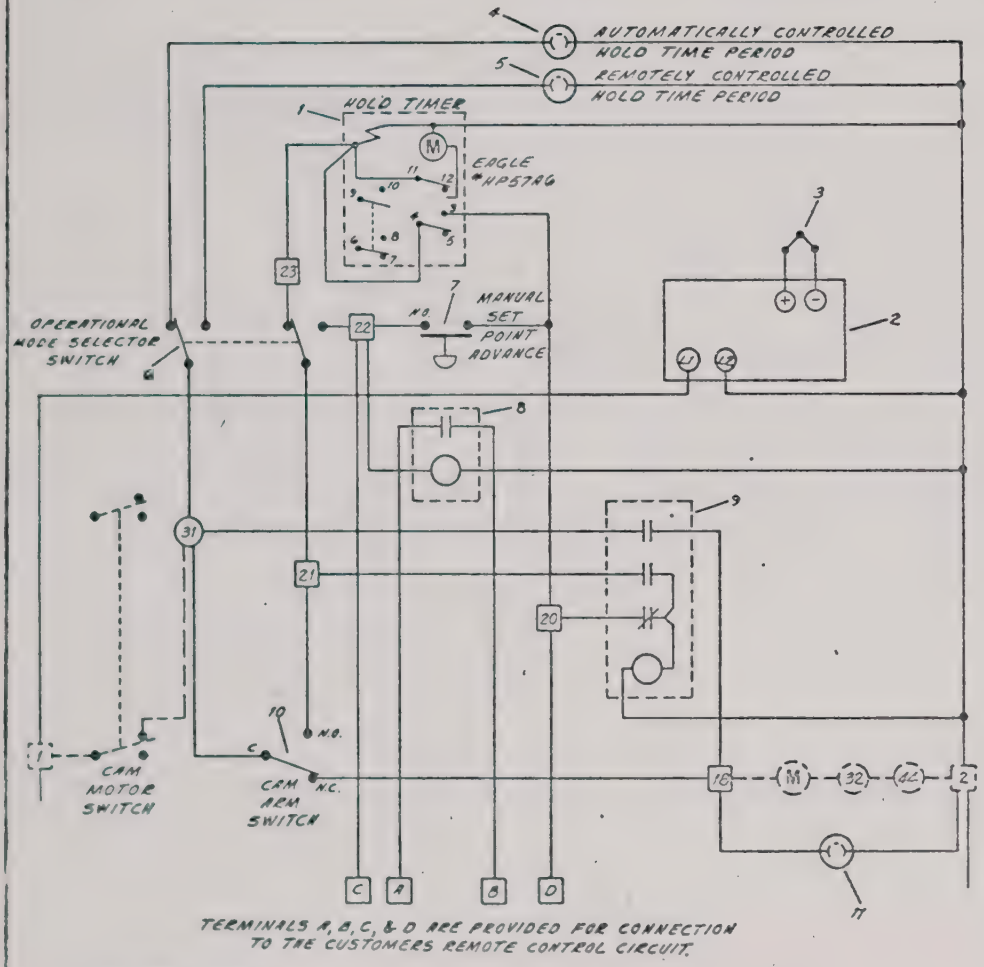
*PARTS NOT SHOWN

Parts shipped F.O.B. Blue Island, Illinois. When ordering parts give Model No., Serial No., Voltage and Part No. PROFRIGERA, A [illegible]

SUPPLEMENTARY WIRING DIAGRAM & PARTS LIST

WO 4936 (JOB NUMBER) USE WITH MASTER WO 311

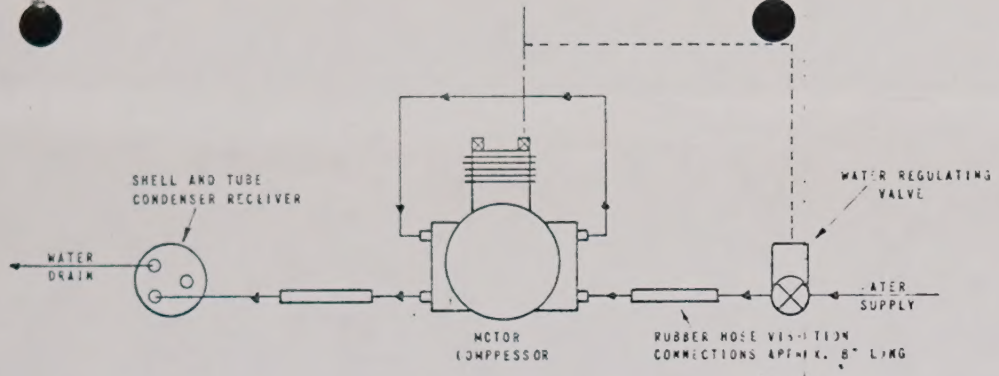
MODEL NO. 1002-3P8X DATE 4-26-74 CUSTOMER NAVAL RESEARCH



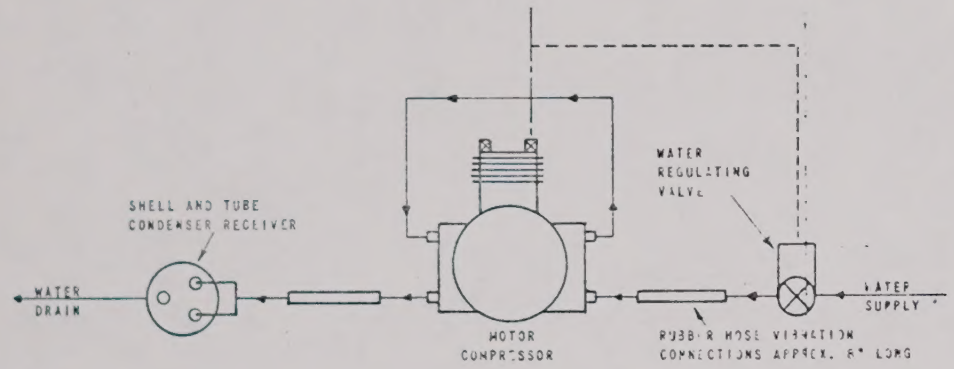
ITEM	DESCRIPTION	PART NO.	QUANTITY
1	Hold Timer	Eagle #HP57A6	1
2	Recorder	C02B-1-1	1
3	Thermocouple	C11B-2	1
4	Automatic Mode Pilot Light	E06B-1	1
5	Remote Mode Pilot Light	E06B-1	1
6	Mode Selector Switch	E16A-2	1
7	Manual Advance Pushbutton	E16C-1	1
8	Remote Mode Relay	E02C-1	1
9	Cam Motor Latching Relay	E02C-6	1
10	Cam Arm Microswitch	Supplied W/#74	
11	Cam Motor Pilot Light	E06B-1	1

NOTES:

1. Continuity across terminals A and B will be completed when the cam pin activates the cam arm microswitch caused by the rotation of the cam.
2. Completing a circuit across terminals C and D by a momentary contact will automatically advance the cam to the next temperature set point. The cam will stop rotating and hold at the cam pin location.
3. A panel mounted, manual set point advance pushbutton switch is provided to override the remote control, if so desired.
4. Temperature set point hold periods can be omitted for a specific program by removing the individual pin, or pins, from the cam.



SINGLE STAGE REFRIGERATION WATER PIPING
DIAGRAM FOR USE WITH CITY WATER



SINGLE STAGE REFRIGERATION WATER PIPING
DIAGRAM FOR USE WITH TOWER WATER

NOTE:

ALL WATER PIPING TO BE WITH O.D. SIZE HARD COPPER TUBING, EXCEPT FOR RUBBER HOSE VIBRATION CONNECTIONS AT COMPRESSOR AND PIPING BETWEEN WRV AND WATER SUPPLY COUPLING WHICH IS GALVANIZED PIPE FOR THE SUPPORT OF THE WRV. ALL PIPING TO BE SUPPORTED AS REQUIRED. FOR PROPER LINE SIZES, REFER TO THE STANDARD WATER PIPE SIZE CHART.

NO. I-116-13

SINGLE STAGE REFRIGERATION
WATER PIPING DIAGRAMS

DATE	DRAWN BY	CHECKED BY
8-11-66	DJV	

Remove autoformers
change X'3 to X2

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